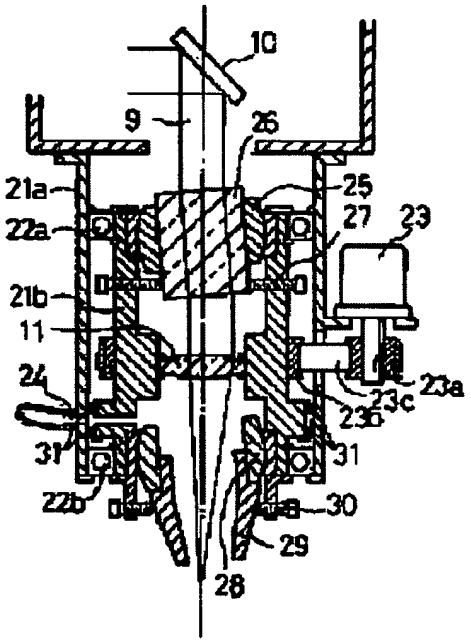
LASER BEAM CUTTING METHOD AND DEVICE THEREFOR

AC

Patent number: JP6039571
Publication date: 1994-02-15
Inventor: SAKURAI SHIGEYUKI; OGATA KOJIRO; MITSUYANAGI NAOKI; TADA NOBUHIKO; SHIMOMURA YOSHIAKI
Applicant: HITACHI CONSTRUCTION MACHINERY
Classification:
- international: B23K26/00; B23K26/06; B23K26/14
- european:
Application number: JP19920201274 19920728
Priority number(s): JP19920201274 19920728

Abstract of **JP6039571**

PURPOSE:To obtain a sound product in which no dross is stuck on its cut surface, no spatters is scattered on the surface and the cut surface is vertical to the product surface, in a laser beam cutting method and its device. CONSTITUTION:In the laser beam cutting device, the incident angle of laser beam 9 and the jetting angle of assist gas are inclined to the normal of a work by a beam parallel 26 and a nozzle 29 supported respectively by spherical bearings 25, 28 and the incident angle of the laser beam 9 and the jetting angle of the assist gas are faced relatively to each other. Further, the incident angle of the laser beam 9 and the jetting angle of the assist gas are adjusted respectively by a beam parallel operating screw 26 and a nozzle operating screw 30. Furthermore, a rotary inner tube 21b is rotated by a motor 23 to change the direction of incidence of the laser beam 9 in response to the cutting direction of the work.



* NOTICES *

1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

CLAIMS

[Claim(s)]
[Claim 1] The laser beam oscillated from a laser oscillation machine is guided to the work piece laid in the trolley table. In the laser-beam-cutting approach of making said work piece condensing said laser beam with a condenser lens, moving said trolley table, blowing off the assist gas which shields the condensing section of said laser beam on said work piece, and cutting said work piece The laser-beam-cutting approach characterized by making the jet angle which makes the incident angle and said assist gas to said work piece of said laser beam blow off to said work piece incline to the normal of said work piece, and making both counter relatively.
[Claim 2] The laser-beam-cutting approach according to claim 1 characterized by the ability to adjust the incident angle to said work piece of said laser beam, and the jet angle of said assist gas furthermore.
[Claim 3] The laser-beam-cutting approach according to claim 2 characterized by the ability of the direction of incidence to said work piece of said laser beam to change according to the cutting direction of said work piece furthermore.
[Claim 4] The focal location of said laser beam which condenses on said work piece is the laser-beam-cutting approach according to claim 2 or 3 characterized by the eternal thing by modification of the incident angle to said work piece of said laser beam, and the direction of incidence.
[Claim 5] A laser oscillation machine and the trolley table to which a work piece is laid and said work piece is moved, The laser beam outputted from said laser oscillation machine Said guiding means which carries out work-piece induction, The condenser lens which makes said laser beam guided to said work piece condense, and an assist-gas jet means to spout the assist gas which shields the condensing section of said laser beam on said work piece, It has the control means which controls the exposure to said work piece of said laser beam by said guiding means, and migration of said trolley table. In the laser beam cutting equipment which is made to condense said laser beam on said work piece, is made to move a trolley table, and cuts said work piece Laser-beam-cutting equipment characterized by having the inclination means which make the jet angle which makes the incident angle and said assist gas to said work piece of said laser beam blow off to said work piece incline to the normal of said work piece, and both are made to counter relatively.
[Claim 6] Laser-beam-cutting equipment according to claim 5 characterized by having an incident angle adjustment means to adjust the incident angle to said work piece of said laser beam furthermore, and a jet angle adjustment means to adjust the jet angle of said assist gas.
[Claim 7] Laser-beam-cutting equipment according to claim 6 characterized by having a direction modification means of incidence to change the direction of incidence to said work piece of said laser beam according to the cutting direction of said work piece furthermore.
[Claim 8] Said incident angle adjustment means and said direction modification means of incidence are laser-beam-cutting equipment according to claim 6 or 7 characterized by making eternal the focal location of said laser beam which condenses on said work piece.

[Translation done.]

* NOTICES *

1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Industrial Application] This invention relates to the laser-beam-cutting approach and equipment which can improve the quality of the work piece cut.
[0002]
[Description of the Prior Art] Cutting processing using a laser beam is used in the various field of a machine, an electron, and a semi-conductor, and especially highly precise cutting processing of the sheet metal by laser-beam-cutting equipment has spread widely. Drawing 6 explains each configuration of the optical system of the processing head which are the configuration of conventional laser-beam-cutting equipment, and its important section.
[0003] As shown in drawing 6 , conventional laser-beam-cutting equipment A laser beam The laser oscillation machine 51 to output and the work piece 52 which is a workpiece It carries and is the inside of a horizontal plane (). [X shaft-orientations] And so that X-Y table [which can move to Y shaft orientations freely] 53, Z table [which is made to move the laser oscillation machine 51 in the vertical direction (Z shaft orientations)] 54, processing head [which was attached to the laser oscillation machine 51] 55, and processing head 55 base may be attended at a work piece 52 The attached nozzle 56, the power source 57 which supplies the laser oscillation output in the laser oscillation machine 51, the migration actuation within the horizontal plane of X-Y table 53 (X shaft orientations and Y shaft orientations), It has the controller 58 which controls migration actuation of the vertical direction of the Z table 54, and oscillation actuation of the laser oscillation machine 51 by automatic or hand control.
[0004] In the laser-beam-cutting equipment which has such a configuration, a laser beam carries out incidence to the processing head 55 from the laser oscillation machine 51, and this laser beam is the processing head 55. It is guided to a nozzle 56 by the bending mirror (not shown) which constitutes internal optical system. With a nozzle 56, it is fully condensed with a condenser lens (not shown) so that it may have the necessary energy density which enables cutting in respect of processing of a work piece 52. The condensed laser beam is outputted outside from the point of a nozzle 56, and is irradiated by the work piece 52. Moreover, although not illustrated, an assist gas blows off from the point of this nozzle 56 in same axle with a laser beam.
[0005] Cutting processing using the above-mentioned laser beam is performed as follows. First, a location is performed by making it operate in the vertical direction and adjusting the Z table 54 so that the focal location of the condensed laser beam may come to the processing side of a work piece 52. Next, under control of a controller 58, an assist gas is supplied, oscillation actuation of the laser oscillation machine 51 is carried out, and a laser beam is irradiated on a work piece 52. It is condensed until it becomes sufficient heat energy, the part by which work-piece 52 front face was irradiated fuses this laser beam, this serves as a heat source, this melting advances toward the depth direction one by one from a front face, a work piece 52 is penetrated soon, and a hole is made in a work piece 52. And X-Y table 53 is moved by the necessary locus under control of a controller 58, and cutting processing is performed by moving a laser beam along with the part which should be cut (it is called the 1st conventional technique above).
[0006] As mentioned above, in cutting processing by the laser beam, although the front face of the work piece 52 which was made to condense a laser beam and was fused serves as a heat source, that melting advances and it finally penetrates, most melts at this time are blown away by a laser beam and the assist gas which blows off in same axle. However, it is not blown away completely, but a part adheres to the both sides of the edge of the rear face of work-piece 52 cutting plane, this gets cold, and this melt (it may be hereafter called dross) forms weld flash. When such weld flash existed, and becoming the cause which produces an error dimensional when building the processed work piece 52 into a product as it is or including especially in electronic parts, there was a trouble that there was a possibility of this weld flash dropping out and making an electronic circuitry short-circuiting. Therefore, in many cases, secondary elaboration is further needed in order to avoid such evil.
[0007] Moreover, in the phase of cutting processing by the above-mentioned laser beam, before melting arrived at the rear face from the work-piece front face, the spatter dispersed on the work-piece front face in many cases, and the quality of the cut front face of a product might deteriorate.
[0008] the above troubles -- receiving -- the conventional technique given in JP,56-74388,A -- if it is, the cutting (dross loess cutting) approach of not making dross adhering to the product which carried out cutting processing as follows is indicated. That is, like drawing 7 , eccentricity of the optical axis of a laser beam 61 and the shaft of a nozzle 62 was carried out, the external force on which eccentricity of the optical axis of a laser beam 61 and the core of an assist-gas style is carried out, and an assist gas exerts them was used, and dross 63 is pushed aside in one side of the cutting part 64. Thus, when the optical axis of a laser beam 61 and the core of an assist-gas style are carrying out eccentricity, dross 63 adheres to the edge of the rear face of work-piece 65 cutting plane of the strong one of an assist-gas style. Dross is not made to adhere to the ingredient by the side of drawing Nakamigi, but dross is made to adhere to the ingredient of the left-hand side in drawing in drawing 7 . And the healthy ingredient to which dross has not adhered can be used as a product by using a right-hand side ingredient as a product, and making a left-hand side ingredient into ** material (it is called the 2nd conventional technique above).
[0009]
[Problem(s) to be Solved by the Invention] According to the conventional technique of the above 1st, dross adhered to the both sides of the

edge of the rear face of a work-piece cutting plane, this got cold, it became weld flash, and there was a trouble of having become the cause of the dimensional error in the case of including in a product, or becoming the short cause of the electronic circuitry in the case of including especially in electronic parts. Moreover, secondary elaboration was required in order to avoid such evil. Furthermore, a spatter may disperse on a work-piece front face, and, thereby, the surface quality of a product might deteriorate.

[0010] Moreover, according to the conventional technique of the above 2nd, the healthy ingredient to which dross has not adhered can be used as a product by making dross adhere to the direction of ** material. However, the side used as a product might not become a perpendicular cutting plane, i.e., a straight cutting plane, to the work-piece front face like drawing 7 , but this might cause a dimension error.

[0011] Moreover, as shown to drawing 8 in a sectional view in this case, the cutting plane bent to the strong one of an assist-gas style in many cases, and the cutting plane of a product did not turn into a straight cutting plane by this, either.

[0012] Furthermore, in this technique, the problem to which a spatter disperses on a work-piece front face is not solved.

[0013] In addition, although the approach only the same include angle makes the incident angle and nozzle of a laser beam both incline using the 1st conventional technique is also considered and dross can be made to adhere to the direction of ** material also in this case as shown in drawing 9 , the cutting plane of a product does not turn into a straight cutting plane too.

[0014] The purpose of this invention is offering the laser-beam-cutting approach and equipment with which dross's does not adhere to a cutting plane, and a spatter's does not disperse on a front face, and a healthy product whose cutting plane's is perpendicular to a front face is obtained.

[0015]

[Means for Solving the Problem] In the laser-beam-cutting approach according to this invention in order to attain the above-mentioned purpose The laser beam oscillated from a laser oscillation machine is guided to the work piece laid in the trolley table. In the laser-beam-cutting approach of making said work piece condensing said laser beam with a condenser lens, moving said trolley table, blowing off the assist gas which shields the condensing section of said laser beam on said work piece, and cutting said work piece The jet angle which makes the incident angle and said assist gas to said work piece of said laser beam blow off to said work piece is made to incline to the normal of said work piece, and both are made to counter relatively.

[0016] The incident angle to said work piece of said laser beam and the jet angle of said assist gas can be adjusted further preferably here.

[0017] Moreover, the direction of incidence to said work piece of said laser beam can change preferably according to the cutting direction of said work piece further.

[0018] Moreover, the focal location of said laser beam which condenses on said work piece is eternal preferably by modification of the incident angle to said work piece of said laser beam, and the direction of incidence.

[0019] In laser-beam-cutting equipment according to this invention in order to attain the above-mentioned purpose A laser oscillation machine and the trolley table to which a work piece is laid and said work piece is moved, The laser beam outputted from said laser oscillation machine Said guiding means which carries out work-piece induction, The condenser lens which makes said laser beam guided to said work piece condense, and an assist-gas jet means to spout the assist gas which shields the condensing section of said laser beam on said work piece, It has the control means which controls the exposure to said work piece of said laser beam by said guiding means, and migration of said trolley table. In the laser beam cutting equipment which is made to condense said laser beam on said work piece, is made to move a trolley table, and cuts said work piece It has the inclination means which make the jet angle which makes the incident angle and said assist gas to said work piece of said laser beam blow off to said work piece incline to the normal of said work piece, and both are made to counter relatively.

[0020] It has preferably an incident angle adjustment means to adjust the incident angle to said work piece of said laser beam further, and a jet angle adjustment means to adjust the jet angle of said assist gas here.

[0021] Moreover, it has preferably a direction modification means of incidence to change the direction of incidence to said work piece of said laser beam according to the cutting direction of said work piece further.

[0022] Moreover, said incident angle adjustment means and said direction modification means of incidence make eternal preferably the focal location of said laser beam which condenses on said work piece.

[0023]

[Function] In this invention constituted as mentioned above, by making the jet angle which makes an assist gas blow off to a work piece incline to the normal of a work piece, it is pushed aside in the direction of one side of a work piece in which dross is cut according to the external force which an assist-gas style does, and adheres to the cutting plane of one of the two of the cut work piece. Moreover, according to the external force which the above-mentioned assist-gas style does, a spatter disperses only on the front face of the near work piece to which dross adhered and does not disperse in the front face of the work piece of another side.

[0024] Moreover, since the laser beam which condenses on a work piece serves as a beam of light of a cone form so that a focus may be connected to a work-piece front face, the hole inside opened in the work piece processed as the incident angle of a laser beam is perpendicular to a work-piece front face turns into a conical surface, and a cutting plane becomes slanting. In this invention, if this incident angle is suitably chosen by making the incident angle to the work piece of a laser beam incline to the normal of a work piece, since the hole of the above-mentioned conical surface inclines, the cutting plane of one of the two of the cut work piece turns into a perpendicular cutting plane, i.e., a straight cutting plane, to a work-piece front face, and another side serves as a cutting plane of the slant which is not straight.

[0025] Furthermore, by making the jet angle which makes an assist gas blow off to a work piece, and the incident angle to the work piece of a laser beam counter relatively, dross adheres to the side whose cutting plane is not straight among the work pieces cut, a spatter disperses, on the other hand, dross does not adhere to a side with a straight cutting plane, or a spatter does not disperse. The near work piece with which said cutting plane was straight, the near work piece with which dross does not adhere or a spatter does not disperse was used as a product, the cutting plane of another side was not straight with a work piece, dross adhered, and the spatter dispersed is made into ** material. Therefore, the cut product will become healthy.

[0026] Moreover, by adjusting the incident angle to the work piece of a laser beam, and the jet angle of an assist gas, the cutting plane by the side of a product becomes perpendicular, it is certainly pushed aside by dross at a ** material side, and a spatter disperses in a ** material side certainly.

[0027] Moreover, by changing the direction of incidence to the work piece of a laser beam according to the cutting direction of a work piece, even if the cutting direction changes according to cutting, the direction of incidence of a laser beam follows the change, and the incident angle

of a laser beam becomes the optimal to a work-piece front face.
[0028] Moreover, a desired cutting location is cut correctly without a gap or an error by that the focal location of the laser beam which condenses on a work piece is eternal even if the incident angle and the direction of incidence of a work piece of a laser beam are changed.
[0029]
[Example] Just, ** is explained to the laser-beam-cutting equipment and the approach by one example of this invention, while drawing 1 refer to ****5 . First, the configuration of the laser-beam-cutting equipment by this example is explained. Drawing 1 is the schematic diagram of the configuration of this equipment. As shown in drawing 1 , this equipment A laser beam The laser oscillation machine 1 to output and the work piece 2 which is a workpiece It carries and is the inside of a horizontal plane (). [X shaft-orientations] And so that the base of X-Y table 3 which can move to Y shaft orientations freely, the Z table 4 made to move the laser oscillation machine 1 in the vertical direction (Z shaft orientations), the processing head 5 attached to the laser oscillation machine 1, and the processing head 5 may be attended at a work piece 2 The power source 7 which supplies the power for the laser oscillation in the nozzle section 6 and the laser oscillation machine 1 which were attached, the migration actuation within the horizontal plane of X-Y table 3 (X shaft orientations and Y shaft orientations), It has the controller 8 which controls migration actuation of the vertical direction of the Z table 4, and oscillation actuation of the laser oscillation machine 1 by automatic or hand control.
[0030] Drawing 2 is drawing explaining the principle of an exposure of the laser beam to the work piece by the laser-beam-cutting equipment shown in drawing 1 . In addition, this drawing is a principle Fig. and is later mentioned using drawing 3 about the detailed configuration and detailed function of a processing head and the nozzle section. In drawing 2 , a laser beam 9 carries out incidence from the laser oscillation machine 1 to the processing head 5. The bending mirror 10 is formed in the optical system inside the processing head 5, a laser beam 9 is reflected in it, and it guides in the direction of a work piece 2. Moreover, the condenser lens 11 is arranged in the interior of a nozzle 6 in which it is located so that a work piece 2 may be attended, and it is fully condensed with this condenser lens 11 so that it may have the necessary energy density which enables cutting in respect of processing of a work piece 2. The condensed laser beam 9 is outputted outside from the point of a nozzle 6, and is irradiated by the processing location A on a work piece 2. Furthermore, the assist-gas feed hopper 24 is formed in the nozzle 6, and an assist gas blows off from the point of a nozzle 6 in the processing location A in same axle with the above-mentioned laser beam 9.
[0031] In the above-mentioned configuration, cutting processing by the laser beam 9 is performed as follows. The Z table 4 (refer to drawing 1) is operated so that the laser beam 9 condensed with the condenser lens 11 may connect a focus with the location A on the processing side of a work piece 2 with a condenser lens 11, and a location is performed by adjusting the physical relationship of the vertical direction. Then, under control of a controller 8, an assist gas is supplied, oscillation actuation of the laser oscillation machine 1 is carried out, and a laser beam 9 is irradiated on a work piece 2. It is condensed until it becomes sufficient heat energy, the part by which work-piece 2 front face was irradiated fuses this laser beam 9, this serves as a heat source, this melting advances toward the depth direction one by one from a front face, a work piece 2 is penetrated soon, and the hole of a work piece 2 is made. And X-Y table 3 is moved by the necessary locus under control of a controller 8, and cutting processing of a work piece 2 is performed by moving a laser beam 9 along with the part which should be cut.
[0032] Drawing 3 is the block diagram of a processing head and the nozzle section. As shown in drawing 3 , the nozzle section 6 is equipped with the motor 23 which tells rotation to fixed outer case 21a fixed to processing head 5 pars basilaris ossis occipitalis, and the fixed outer case two a1 through belt 23c constructed in Pulleys 23a and 23b at rotation container liner 21b supported free [rotation] and rotation container liner 21b by two bearing 22a and 22b, and the assist-gas feed hopper 24 which supplies an assist gas to the nozzle section 6. moreover, to rotation container liner 21b It is supported by spherical bearing 25. The direction of incidence of a laser beam It is supported by the beam parallel actuation screw 27 which supports the beam parallel 26 and the beam parallel 26 which are made to carry out parallel translation and are changed by two points, and adjusts whenever [tilt-angle], the condenser lens 11 which makes the laser beam from the above-mentioned beam parallel 26 condense on a work piece, and spherical bearing 28. An assist gas The nozzle actuation screw 30 which supports the nozzle 29 and nozzle 29 to spout by two points, and adjusts the tilt angle is attached. Moreover, the seal member 31 is formed in the perimeter of the location which meets the assist-gas feed hopper 24 of rotation container liner 21b, this part serves as a swivel joint, and through this swivel joint, an assist gas is supplied to the interior of rotation container liner 21b, and blows off from a nozzle 29.
[0033] In the above configurations, as mentioned above, it reflects by the bending mirror 10, and a laser beam 9 is guided below (the direction of a work piece 2), and carries out incidence to the beam parallel 26. The direction of incidence carries out the parallel displacement of the laser beam 9 which carried out incidence to the beam parallel 26, and after the optical axis has shifted to the shaft of a condenser lens 11, it carries out incidence in parallel. Whenever [tilt-angle / of this beam parallel 26], with the beam parallel actuation screw 27, it is adjusted manually and the movement magnitude of the parallel displacement of a laser beam 9 is adjusted. Although the laser beam 9 which carried out incidence to the condenser lens 11 is condensed on a work piece 2, since incidence is carried out in parallel to the shaft of a condenser lens 11 as mentioned above, the laser beam 9 condensed with a condenser lens 11 is correctly condensed by the focal location of a condenser lens 11, i.e. a desired cutting location. Moreover, it is adjusted, when this angle of incidence adjusts whenever [tilt-angle / of the beam parallel 26] with the beam parallel actuation screw 27 and it changes the movement magnitude of the parallel displacement of a laser beam 9, although a laser beam 9 inclines to the shaft of a condenser lens 11, therefore the normal of a work piece 2 and carries out incidence. Since the laser beam which condenses on a work piece 2 serves as a beam of light of a cone form so that a focus may generally be connected to a work-piece front face, the hole inside opened in the work piece processed as the incident angle of a laser beam is perpendicular to a work-piece front face turns into a conical surface, and a cutting plane becomes slanting. However, in this example, a laser beam 9 inclines to the shaft of a condenser lens 11, therefore the normal of a work piece 2, since incidence is carried out, if this incident angle is chosen suitably, the cutting plane of one of the two of the cut work piece 2 can be made into a perpendicular cutting plane, i.e., a straight cutting plane, to a work-piece front face, and another side can be made into the cutting plane of the slant which is not straight.
[0034] Moreover, an assist gas is supplied to the interior of rotation container liner 21b through a swivel joint from the assist-gas feed hopper 24, and blows off from a nozzle 29. Whenever [tilt-angle / of a nozzle 29], it is manually adjusted with the nozzle actuation screw 30, and the jet angle which makes an assist gas blow off to a work piece 2 is adjusted. Whenever [tilt-angle / of this nozzle 29], i.e., the jet angle of an assist gas, inclines to the shaft of a condenser lens 11, i.e., the normal of a work piece 2, and it is set up so that it may counter relatively [laser beam / 9]. It is made for a spatter to disperse, and, and a spatter can be prevented from dross's adhering to a side with a straight cutting plane

on the other hand, or dispersing by this, as shown in drawing 4 . [that dross adheres to the work piece of the side whose cutting plane is not straight] In addition, the spatter which dispersed in drawing 4 is not drawn. Among these, the near work piece with which the latter cutting plane was straight, the near work piece with which dross does not adhere or a spatter does not disperse was used as a product, the cutting plane of another side was not straight with a work piece, dross adhered, and the spatter dispersed is made into ** material. Therefore, the cut product will become healthy.

[0035] Moreover, rotation container liner 21b rotates by telling rotation of a motor 23 through belt 23c constructed in Pulleys 23a and 23b. Rotation container liner 21b is equipped with the beam parallel 26, the condenser lens 11, and the nozzle 29 as mentioned above, and these are the above-mentioned beam parallel 26 and a condenser lens by rotation of rotation container liner 21b. While whenever [optical angular-relation-ship / of 11 / and tilt-angle / of a nozzle 29] has been eternal, it rotates around the shaft of a condenser lens 11. That is, the direction of incidence of the laser beam 9 to a work piece 2 rotates, and is changed. Even if that cutting direction changes with this according to cutting a work piece 2, that change can be made to be able to follow, the direction of incidence of a laser beam 9 can be made to change into it, and the incident angle of a laser beam 9 becomes the optimal to work-piece 2 front face. Since incidence of the laser beam 9 is carried out always in parallel with the shaft of a condenser lens 11, the laser beam 9 condensed with a condenser lens 11 is correctly condensed by modification of the still more above directions of incidence of a laser beam 9 in the focal location of a condenser lens 11, i.e., a desired cutting location.

[0036] The example of processing which used the above laser-beam-cutting equipments for below is explained. As shown in drawing 5 , cutting processing shall be carried out by the laser beam, setting the slash section to product 40a, and using an outside part as ** material 40b. Moreover, the processing locus 41 is taken in the direction of the arrow head in drawing, and the velocity vector which is the cutting direction is expressed with 42. Make a nozzle 29 incline in the direction of 43A which is the direction counterclockwise rotated 90 degrees from the direction of a velocity vector 42, on the other hand, a laser beam 9 is made to incline in the direction of 43B which is the direction clockwise rotated 90 degrees from the direction of a velocity vector 42, and both are made to counter in the location shown in drawing. Whenever [these tilt-angles], it is preliminary experiment beforehand and the optimal conditions are chosen in consideration of the gas pressure of the quality of the material of a work piece 2 and thickness, and an assist gas etc. It is pushed aside by dross in the direction of 43A by this according to the external force which an assist gas does, and adheres to the direction of ** material 40b, and a spatter also disperses in the direction of 43A, i.e., ** material 40b. Moreover, since a laser beam 9 inclines in the direction of 43B, the cutting plane of product 40a turns into a straight cutting cross section. Although cutting processing is performed along with the processing locus 41 from the location shown in drawing in this condition, rotation container liner 21b is rotated and the direction of incidence to the cutting location of a laser beam 9 is made to follow in footsteps in this cutting direction by making it correspond to change of the velocity vector 42 which is the cutting direction, and controlling a motor 23 in that case. Therefore, the incident angle of the laser beam 9 under cutting processing always becomes the optimal to work-piece 2 front face, and cut product 40a has neither adhesion of dross, nor scattering of a spatter, and will become straight [a cutting plane] and healthy. In addition, the above-mentioned motor is controllable by the controller 8.

[0037] Since according to this example adjust whenever [tilt-angle / of a nozzle 29], and the jet angle of an assist gas is made to incline to the normal of a work piece 2 and the jet angle of an assist gas and the incident angle of a laser beam 9 are made to counter relatively as explained above, dross adheres to the cutting plane of ** material 40b, and it disperses on the front face of the work piece of the ** material 40b also with the same spatter as dross adhered. Therefore, adhesion of the dross to product 40a and scattering of a spatter can be prevented.

[0038] Moreover, since the incident angle to the work piece 2 of a laser beam 9 is made to incline to the normal, the cutting plane of product 40a can be made into a perpendicular cutting plane, i.e., a straight cutting plane, to work-piece 2 front face.

[0039] Moreover, since rotation container liner 21b is rotated and the direction of incidence to the work piece 2 of a laser beam 9 is changed according to the cutting direction of a work piece 2, even if the cutting direction changes according to cutting, the direction of incidence of a laser beam 9 can follow the change, and the incident angle can be made the optimal to work-piece 2 front face.

[0040] Moreover, since the shaft of a condenser lens 11 is set as the laser beam 9 which carries out incidence to a condenser lens 11 to parallel and the focal location is made eternal even if the incident angle and the direction of incidence of a laser beam 9 are changed, a desired cutting location can be cut correctly without a gap or an error.

[0041] In addition, it is not necessary to necessarily discard ****** material, and it can remove adhering dross and the spatter which dispersed, can search a cutting plane straight, can restore it, can be used as a product, and when it is not the soundness remainder strictness of a front face or an end face, it can also be used as it is.

[0042]

[Effect of the Invention] Since according to this invention the jet angle of an assist gas is made to incline to the normal of a work piece and the jet angle of an assist gas and the incident angle of a laser beam are made to counter relatively, dross can adhere to the cutting plane of a product, or it can prevent that a spatter disperses on the surface of a product. Moreover, since the incident angle of a laser beam is made to incline to the normal of a work piece, the cutting plane of a product can be made into a perpendicular cutting plane, i.e., a straight cutting plane, to a work-piece front face. Therefore, a healthy product can be obtained.

[0043] Moreover, since adjustment of the incident angle of a laser beam and the jet angle of an assist gas is enabled, the cutting plane by the side of a product can be made perpendicular, dross can be certainly pushed aside to a ** material side, and a spatter can be certainly dispersed in a ** material side.

[0044] Moreover, since the direction of incidence of a laser beam is changed according to the cutting direction of a work piece, even if the cutting direction changes according to cutting, the direction of incidence of a laser beam can be made to be able to follow it, and the incident angle of a laser beam can be made the optimal to a work-piece front face.

[0045] Moreover, since the focal location of the laser beam by the condenser lens is made eternal also to modification of the incident angle of a laser beam, and the direction of incidence, a desired cutting location can be cut correctly without a gap or an error.

[Translation done.]